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16. ABSTRACT

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17. KEYWORDS
Pavements, grooving, motorcycles, safety, riding quality

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HIGHWAY RESEARCH REPORT

EFFECT OF PAVEMENT GROOVING ON MOTORCYCLE RIDEABILITY

INTERIM REPORT

69-15

STATE OF CALIFORNIA

BUSINESS AND TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

RESEARCH REPORT

NO. M & R 633126-6

Prepared in Cooperation with the U.S. Department of Transportation, Bureau of Public Roads November, 1969

STATE OF CALIFORNIA—TRANSPORTATION AGENCY

RONALD REAGAN, Governor

DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT
5900 FOLSOM BLVD., SACRAMENTO 95819

November, 1969
Interim Report
M&R No. 633126-6

Mr. J. A. Legarra
State Highway Engineer

Dear Sir:

Submitted herewith is a research report titled:

EFFECT OF PAVEMENT GROOVING
ON MOTORCYCLE RIDEABILITY

GEORGE B. SHERMAN
Principal Investigator

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MELVIN H. JOHNSON
Co-Investigators

Assisted by
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Very truly yours,

JOHN L. BEATON
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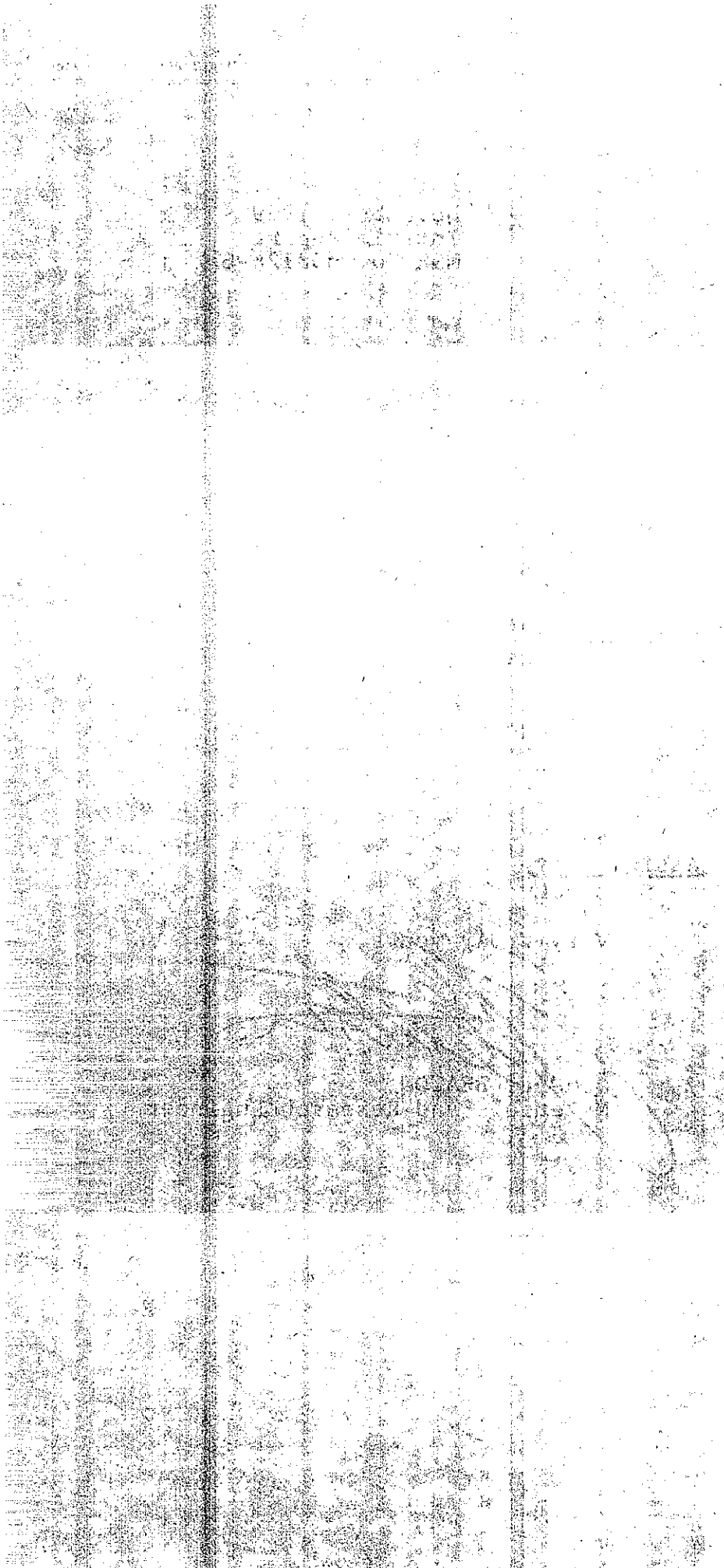

REFERENCE: Sherman, G. B., Skog, J. B. and Johnson, M. H., "Effect of Pavement Grooving on Motorcycle Rideability", State of California, Department of Public Works, Division of Highways, Materials and Research Department, Research Report 633126-6, November, 1969.

ABSTRACT: A study was conducted to determine if the safety of the motorcyclist was impaired by pavement grooving and which pattern of those tested resulted in the least sensation to the cyclist. The six pavement grooving patterns most frequently considered for use on California highways were cut longitudinally into a relinquished PCC section of the State Highway System. Seven motorcycles, ranging from one of the smallest legally allowed on California freeways to one of the largest used, were made available for evaluating these patterns. The evaluation was made by two experienced motorcyclists. The pavement grooving patterns, as tested in this study, did not present a hazardous riding condition to the motorcyclists. In general the lighter machines were more sensitive to the grooving patterns; however, none had a sensitivity level sufficient to cause a control problem. No individual grooving pattern was considered to be consistantly superior, from a motorcycle rideability standpoint.

KEY WORDS: Pavements, grooving, motorcycles, safety, riding quality.

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The authors wish to express their appreciation to the California Highway Patrol, and especially to Mr. Ross Little and Sergeant Larry Piatt, for their cooperation in conducting this study.

The authors wish to thank the County of Yolo for providing the pavement used in this study and the various motorcycle and tire distributors for furnishing the necessary equipment.

This is the sixth in a series of interim reports on a research project dealing with the skid resistance of pavement surfaces. This work was done in cooperation with the U. S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads. The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

INTRODUCTION

The advent of extensive pavement grooving in California brought on reports that grooving patterns resulted in riding sensations to the motorcyclist which were different from that experienced on ungrooved pavements. There have been no reports of motorcycle accidents caused by pavement grooving, only indications that certain grooving patterns and/or machines may result in a "strange feeling" to the cyclist.

The effectiveness of pavement grooving in reducing wet weather accidents has been well documented (1,2) and discontinuing its use would create a safety hazard to the majority of the motoring public. Consequently, the logical course of action was to conduct a study to determine to what extent the safety of the motorcyclist was impaired by pavement grooving and which pattern resulted in the least sensation to the cyclist. Therefore, this study was initiated.

The six pavement grooving patterns most frequently considered for use on California highways were cut longitudinally into a relinquished PCC section of the State Highway System near Sacramento. Seven motorcycles, ranging from one of the smallest legally allowed on California freeways to one of the largest used, were made available for evaluating these patterns. The evaluation was made by two experienced motorcyclists. This report discusses the results of the evaluation and is the sixth in a series of reports dealing with skid resistance studies.

CONCLUSIONS

1. In this study, the pavement grooving patterns, when evaluated with the various motorcycles, did not present a hazardous riding condition. In general, the lighter machines were more sensitive to the grooving patterns; however, none had a sensitivity level sufficient to cause a control problem.

2. No individual grooving pattern was considered to be consistently superior, from a motorcycle rideability standpoint.

EVALUATION PROCEDURE

Six patterns were grooved into the test pavement as shown in Figure 1. As can be seen in this figure, 1/8" x 1/8" on 1/2",

3/4" and 1" centers were tested. One of the test patterns utilized a thinner blade (0.095") at 3/4" centers. Another pattern tested, herein referred to as Style A, consisted of cuts .095" x 1/8" on 3/4" centers with two .095" grooves equally spaced between those on 3/4" centers and not more than 1/16" deep. This particular pattern is used in locations where it is desirable to raise the coefficient of friction of the pavement a significant amount. Christensen Diamond Services Company's Style 15 pattern was also tested. This pattern had previously been reported as one which was superior in increasing the coefficient of friction of smooth pavements (3).

Coefficient of friction determinations were made on the test areas before and after grooving, and the results are shown in Table A. Not much significance, in regard to improving the pavement coefficient of friction, can be noted in these readings, due to the high original values, but they are presented for general information. The test pavement was selected for its overall smooth profile and not for coefficient of friction considerations.

The motorcycles used for the evaluation are shown in Figure 2. The only consideration in the selection of the machines was to encompass the size and weight range normally operated on California freeways. California law requires that a motorcycle must have 15 gross brake horsepower in order to operate on freeways. The 125cc machine used in this evaluation has a 15.2 hp rating and is one of the smallest which would be legally allowed on the freeways. There are machines of approximately this size and weight which do not meet the horsepower requirements and, therefore, would not be on the freeways. The largest and heaviest machine normally used in California is a fully equipped Highway Patrol model. Most of the motorcycles used in this evaluation were relatively new; however, some had had moderate previous usage.

No attempt was made to conduct an extensive evaluation of tire patterns. All of the machines were run with standard equipment street tires. In addition, evaluations were made with the lightest machine equipped with semi-knobby tires on both the front and rear wheels (Figure 3). It is felt that a machine of this weight equipped with that style tire represents a critical evaluation device for the grooving patterns. Evaluation of the patterns was made also by the 250cc and 500cc machines equipped with a full knobby tire on the rear wheel (Figure 4). Here again it is felt that these test conditions were severe from the standpoint of rideability on the patterns. No evaluation was conducted with a machine equipped with a full knobby tire on the front wheel. Separate evaluations were made with the heavy U. S. machine equipped with the new (5.10 x 16) and old style (5.00 x 16) tires used by the California Highway Patrol (Figure 5).

The evaluation was performed by two experienced motorcyclists. One was a uniformed Highway Patrolman and the other a non-uniformed employee of the California Highway Patrol. These two men were of different weight and body structure. The largest one who weighed approximately 195 pounds, was 30 pounds heavier than the smaller framed man.

The evaluation was made at a 40-50 mph speed range as well as a 50-60 mph range. The motorcycles were brought up to the proper speed prior to entering the grooving patterns. The cyclists entered the patterns parallel to the grooves and directly from an ungrooved portion of the pavement. Immediately after each run, the cyclist made a subjective evaluation of the relative sensitivity of the particular motorcycle to the pattern being tested. This sensitivity was defined as that amount of feeling greater than experienced on the ungrooved pavement. Initially it was intended to have some type of grading sheet, with various factors to be evaluated, for the cyclists to mark. However, it was later decided that it would be more meaningful for the cyclists to make an overall subjective statement as to relative sensitivity. One of the cyclists weaved in and out of the grooving patterns, for their entire lengths, at both speed ranges. The sensitivity to this maneuver was also subjectively evaluated and recorded after each run.

Thought was given to placing grooving patterns on curved sections; however, a curved section of PCC pavement, in good condition, could not be made available for test purposes. In any event it was felt that a combination of the straight runs and weaving in and out would give a good initial evaluation of the patterns.

DISCUSSION OF EVALUATION

The subjective evaluations made by the motorcyclists were quantitatively rated in order to make graphical representations (Figures 6 through 18). The plots were obtained by combining the evaluation of the two cyclists. In almost every case, their ratings were the same and therefore it is felt that this combination is justifiable. In cases where sensitivity to weaving in and out was experienced, a definite relative sensitivity to straight runs on the same pattern was also experienced; therefore, this quality is not plotted separately. Generally speaking, there wasn't much sensitivity to weaving in and out of the patterns. The majority of the ratings did not vary with speed and of those that did, as many increased with speed as decreased with speed. In any case there wasn't enough consistancy in the effect of this parameter to justify definite conclusions.

The 1/8" x 1/8" at 1/2" and 1" centers and the Style A patterns, considering all of the motorcycles used, resulted in the least overall sensation to the cyclists (Figures 6, 7 and 10). The two patterns spaced at 3/4" centers resulted in a greater sensation when evaluated by the lighter machines (Figures 8 and 9). However, there are very few 125cc machines and not many 250cc machines on the highways and therefore more emphasis should be put on the reaction of the heavier machines. The Style 15 resulted in the most sensitivity (Figure 11), but here again it should be emphasized that this is only relative riding comfort and that none of the ratings were at a hazardous level.

Figure 12 shows the difference in ratings obtained with street and semi-knobby tires on the 125cc machine. As can be seen, the semi-knobby tires result in somewhat more sensitivity; however, not significantly or consistently. Figure 13 shows a definite increase in sensitivity when the 250cc machine is equipped with a knobby tire on the rear wheel instead of a street tire. When the 500cc machine is equipped with a knobby tire on the rear wheel, there is more sensitivity on some of the patterns (Figure 14). Generally speaking, using semi-knobby tires on both wheels or a full knobby on the rear wheel will result in a "rougher" ride on grooved pavement. This would be expected to be the case on any type of pavement.

Figure 17 shows that the new style tire, presently used on California Highway Patrol motorcycles, results in a significantly improved ride on the 3/4" spaced patterns. Patterns with this spacing are the most predominate on California freeways. Any official reports that Highway Patrol motorcycles were sensitive to grooving patterns were the result of tests made on 3/4" spaced patterns. Further checking on the reports revealed that they were made prior to the time that the Highway Patrol motorcycles were equipped with the new style tires. It is quite evident that the new style tire, which is somewhat wider (5.10 versus 5.00) and has a different tread pattern than the old style (Figure 5), provides an improvement in rideability of the Highway Patrol and heavy U. S. machines on the majority of grooving patterns.

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2. Farnsworth, E. E., "Pavement Grooving on Highways," Pavement Grooving and Traction Studies NASA SP-5073, 1969, National Aeronautics and Space Administration, Washington, D. C., pp. 411-424.

3. Zube, E., Skog, J. B. and Munday, H. A., "Coefficient of Friction of Various Grooving Patterns on PCC Pavement," State of California, Department of Public Works, Division of Highways, Materials and Research Department, Research Report 633126-4, July, 1968.

TABLE A

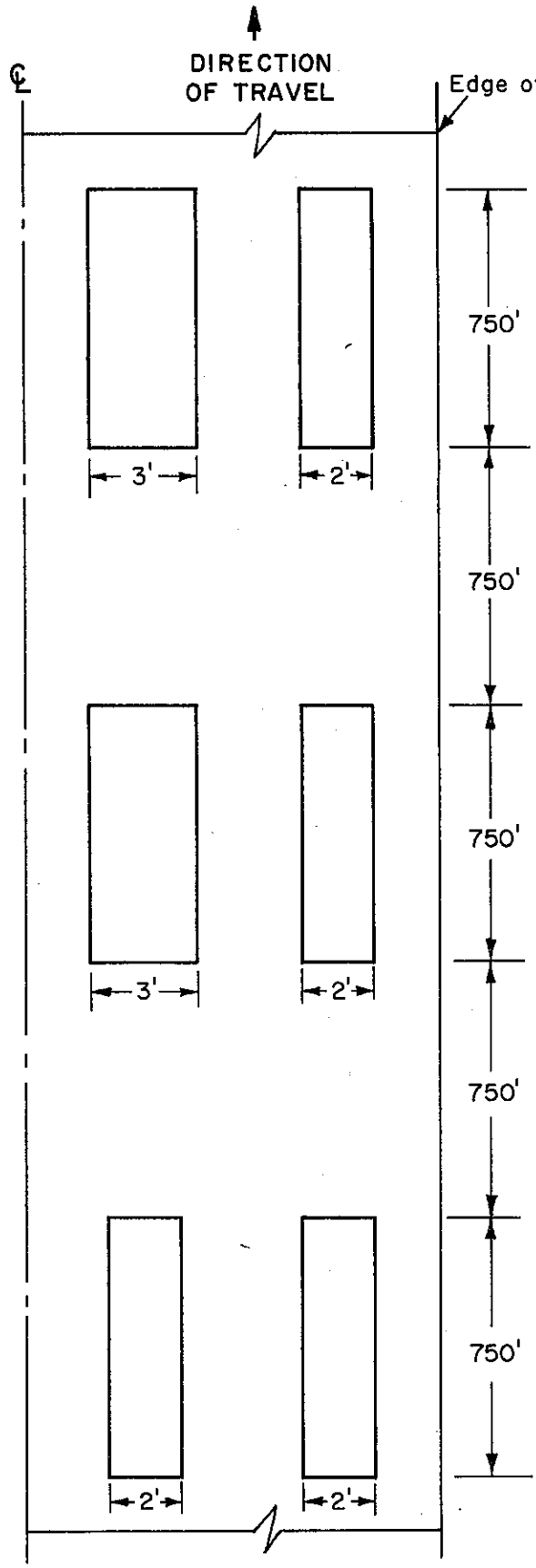
Coefficient of Friction Values

Pattern	Before Grooving	After Grooving
1/8" x 1/8" @ 1/2"	0.37	0.38
1/8" x 1/8" @ 1"	0.36	0.36
1/8" x 1/8" @ 3/4"	0.38	0.39
.095 x 1/8" @ 3/4"	0.38	0.39
Style A	0.40	0.44
Style 15	0.39	0.45

Note: These coefficient of friction readings were obtained under the test conditions of locked wheel, smooth tire, wet pavement and a speed of 50 mph. (Test Method No. California 342-C)

Figure 1

GROOVING PATTERN TEST LAYOUT



Inner Wheel Track:
Style 15

Outer Wheel Track:
Style A

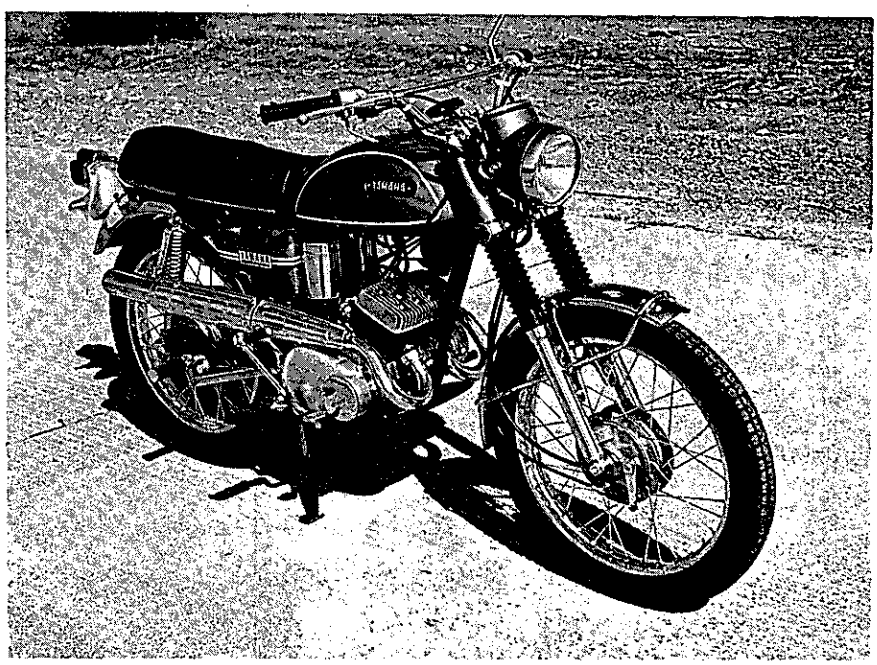
Inner Wheel Track:
.095" x 1/8" at 3/4" centers

Outer Wheel Track:
1/8" x 1/8" at 3/4" centers

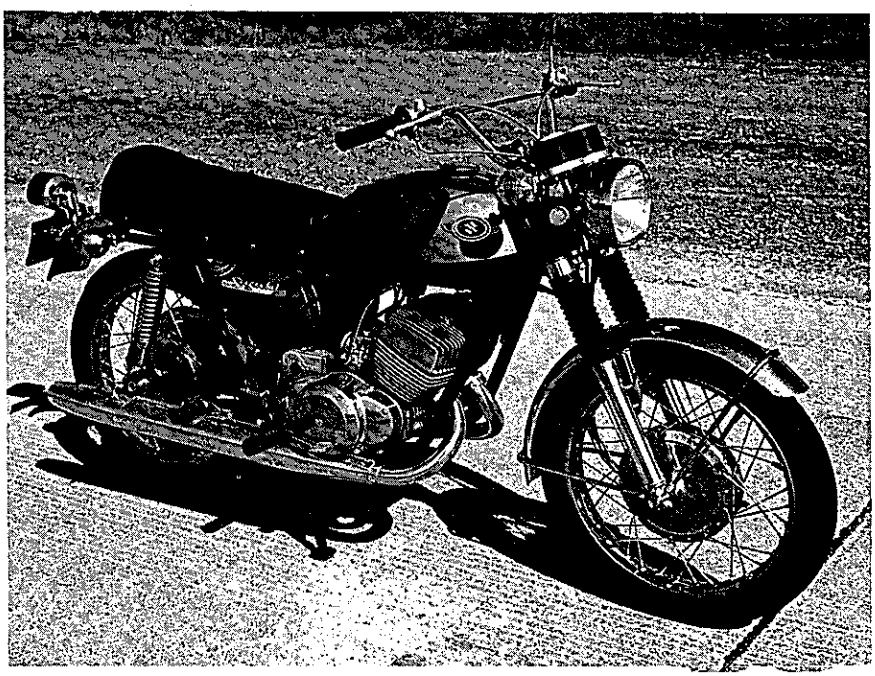
Inner Wheel Track
1/8" x 1/8" at 1" centers

Outer Wheel Track
1/8" x 1/8" at 1/2" centers

Figure 2
Motorcycles Used in Study

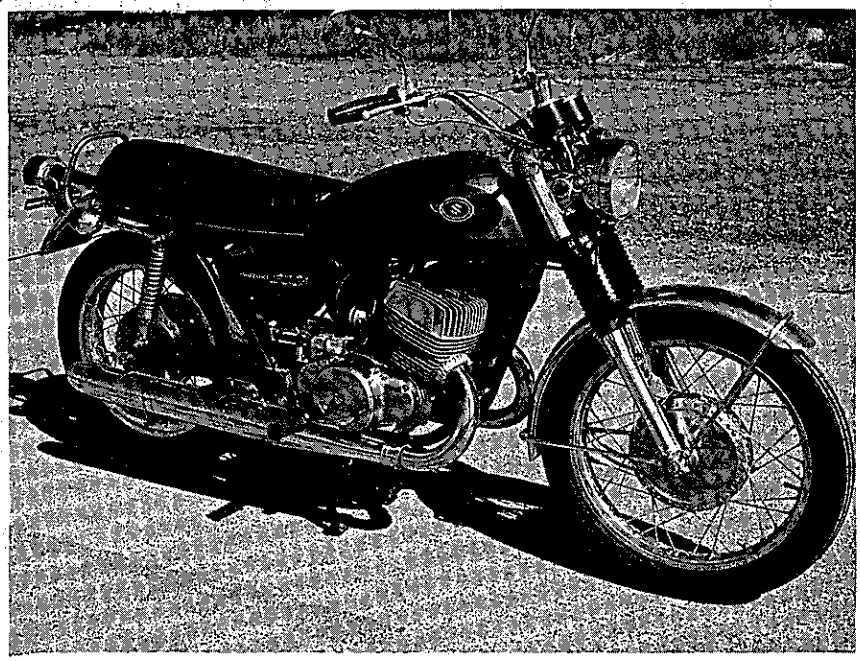


125cc Machine



250cc Machine

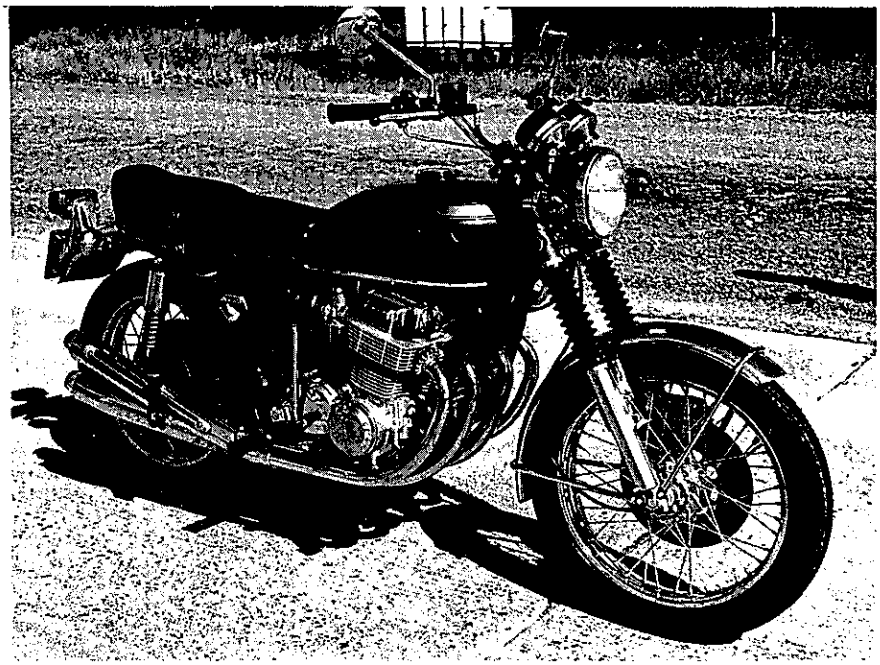
Figure 2 - Cont'd
Motorcycles Used in Study



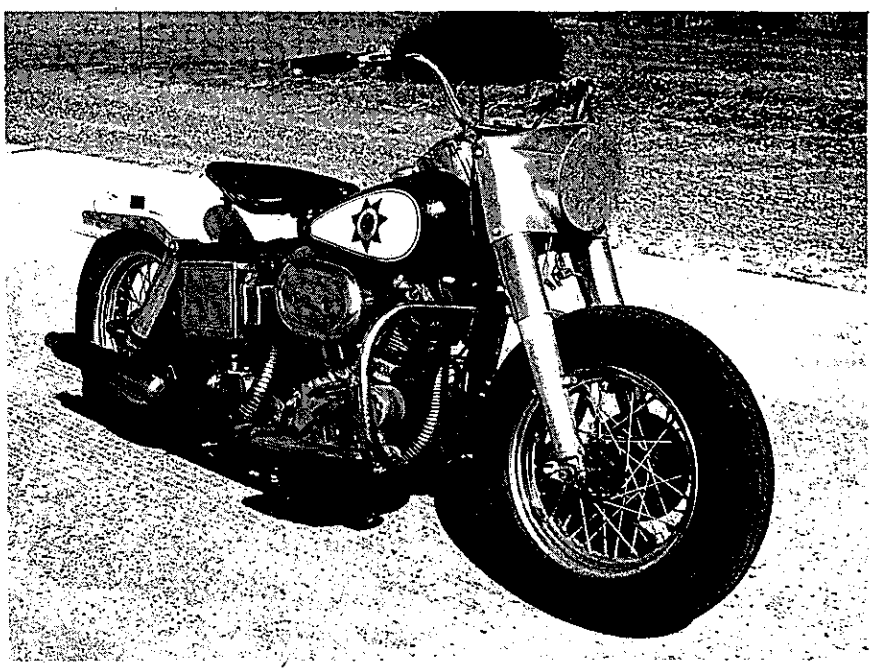
500cc Machine

650cc Machine

Figure 2 - Cont'd
Motorcycles Used in Study

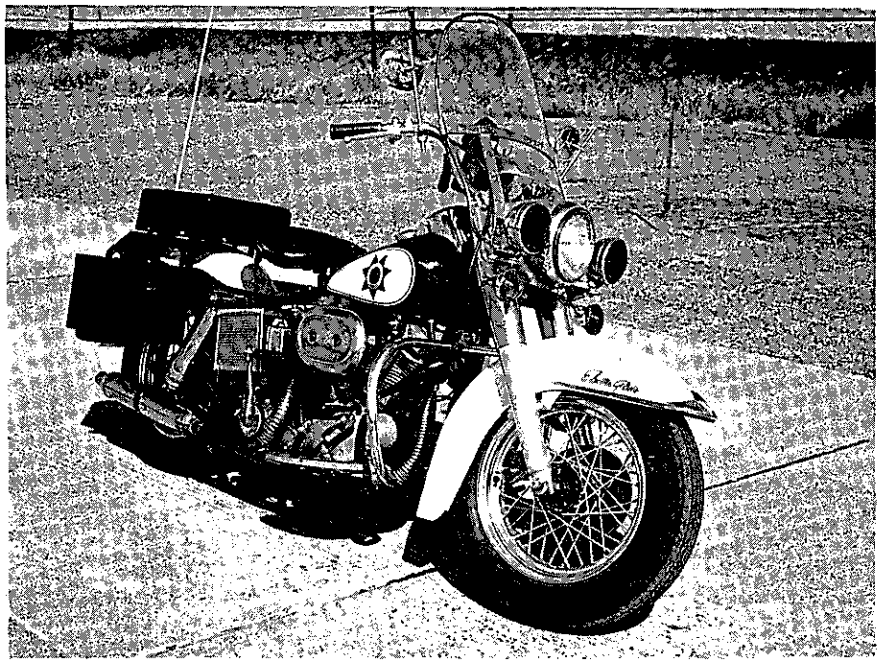


750cc Machine



Heavy U.S. Machine

Figure 2 - Cont'd
Motorcycles Used in Study



CHP Machine

Figure 3
Semi-Knobby Tire Used on 125cc Machine

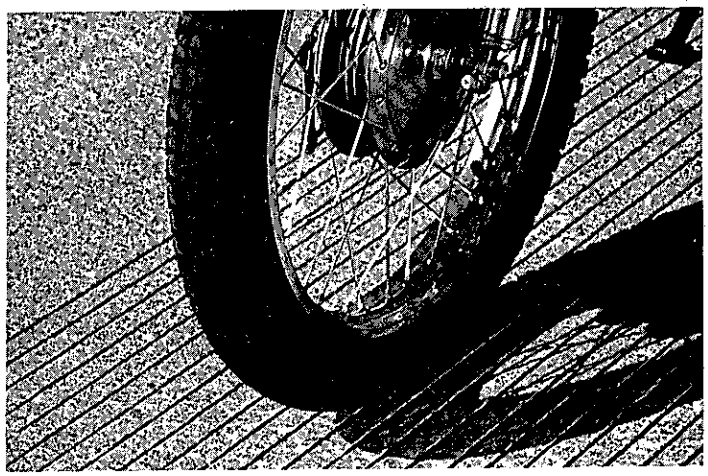
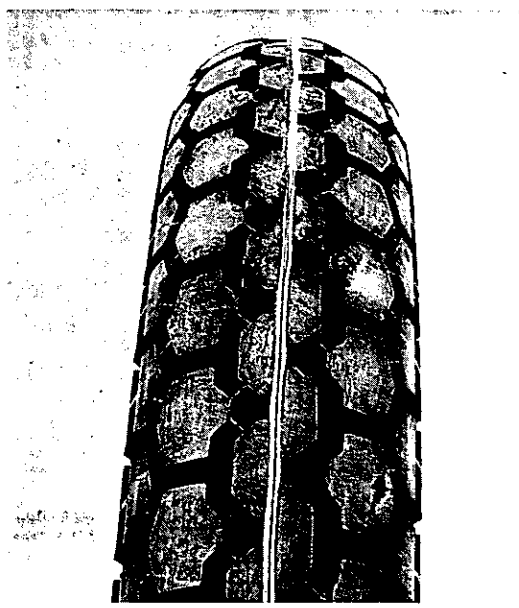


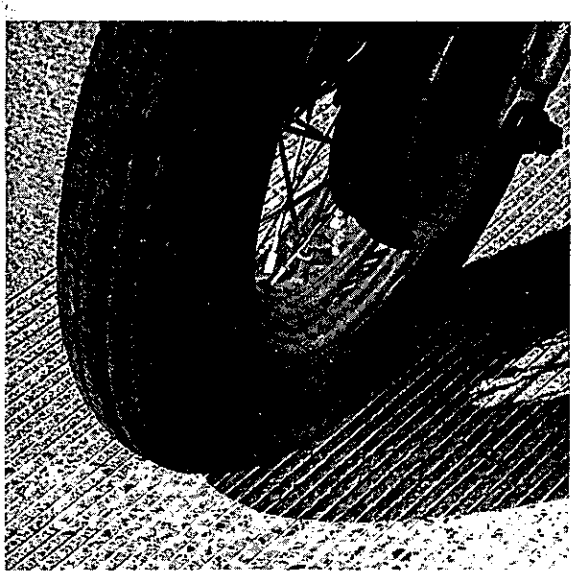
Figure 4
Knobby Tires Used in Study

Used on 500cc Machine

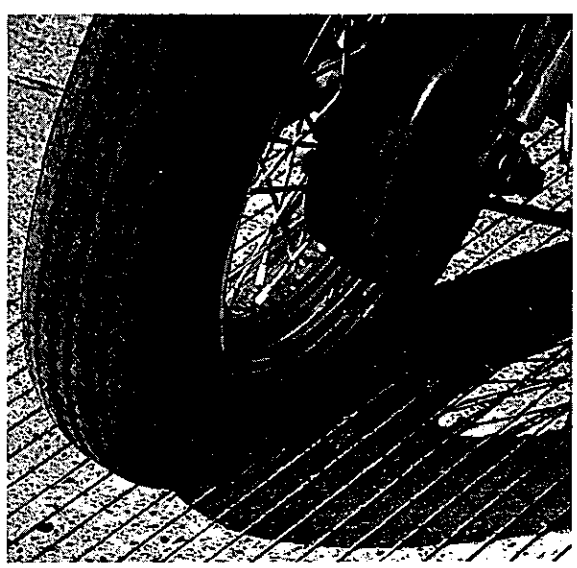


Used on 250cc Machine

Figure 5
Old and New Style CHP Tires



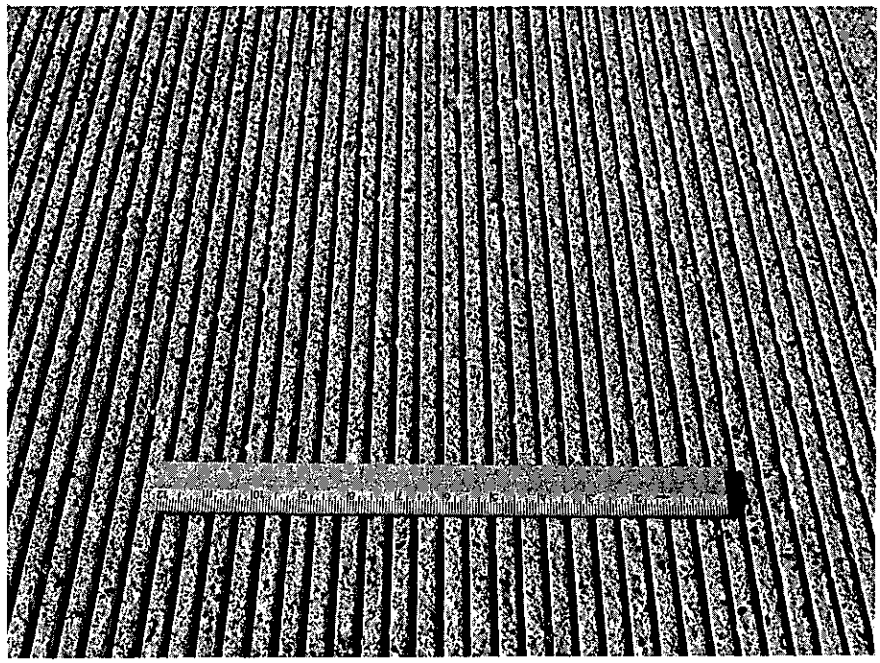
Old Style
(5.00 x 16)



New Style
(5.10 x 16)

Figure 6

1/8" X 1/8" AT 1/2" CENTERS GROOVING PATTERN MOTORCYCLE VS RELATIVE SENSITIVITY



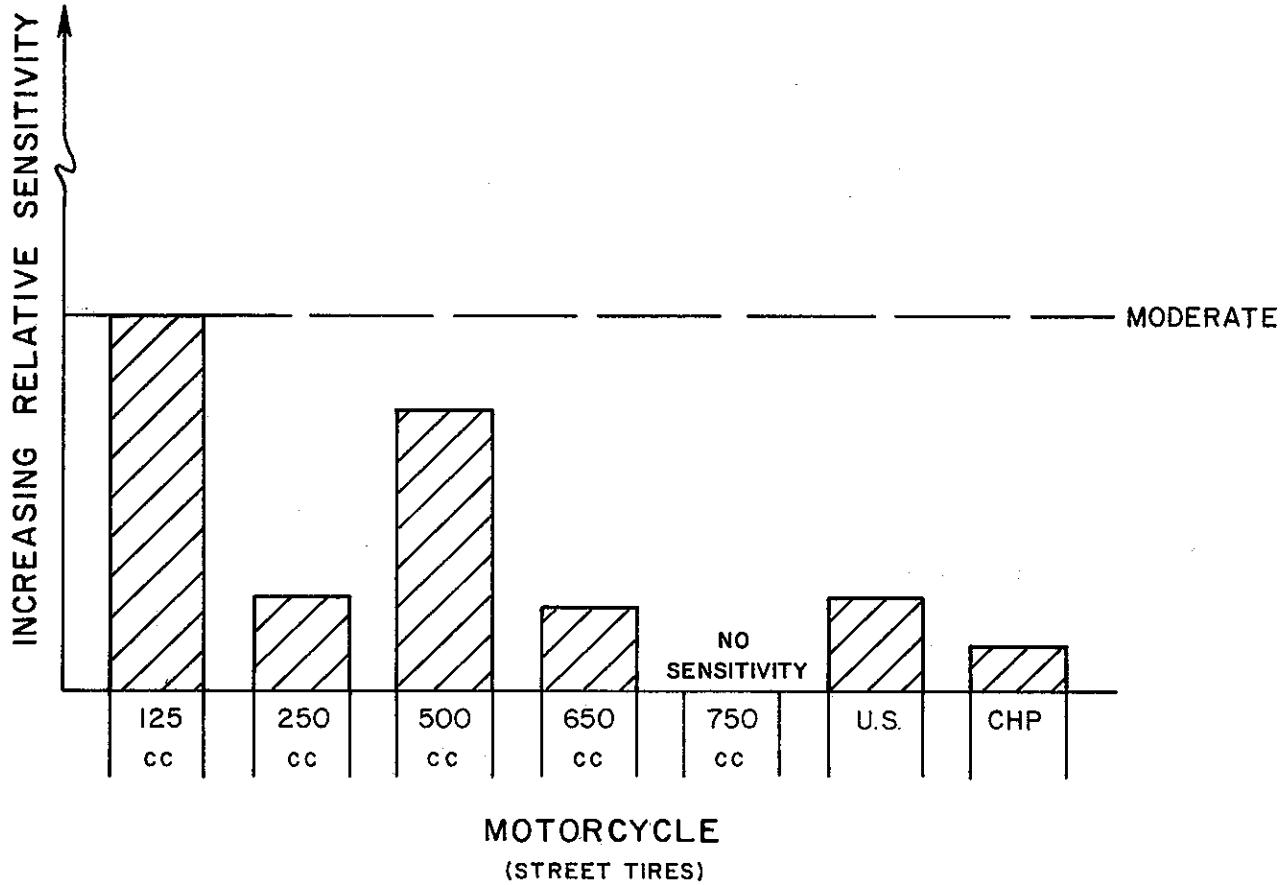
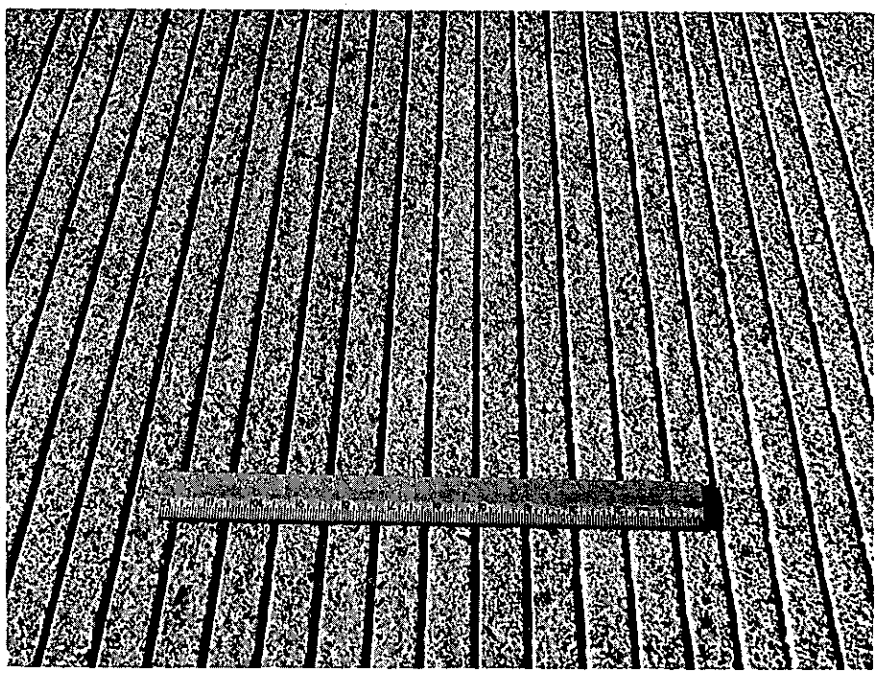


Figure 7

1/8" X 1/8" AT 1" CENTERS GROOVING PATTERN MOTORCYCLE VS RELATIVE SENSITIVITY



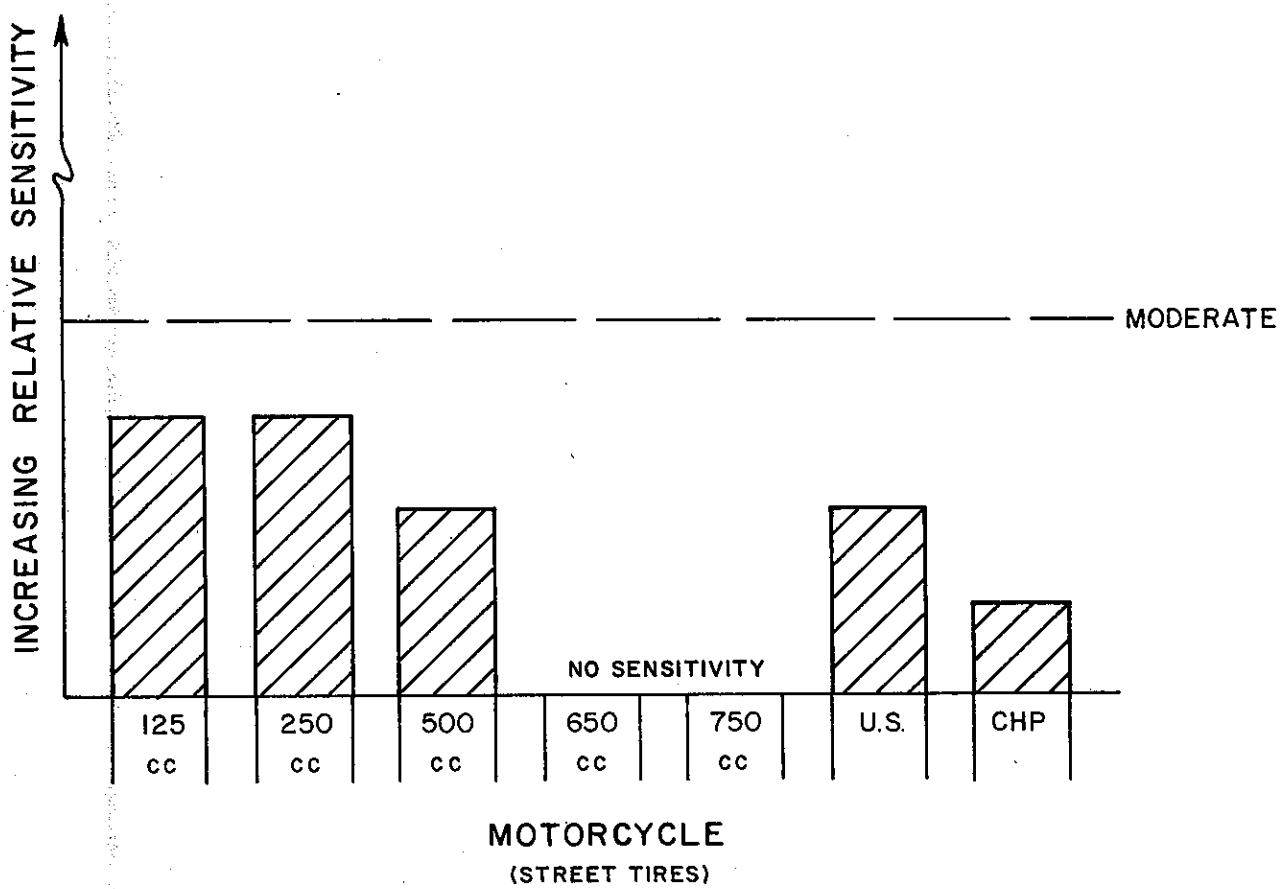


Figure 8

1/8" X 1/8" AT 3/4" CENTERS GROOVING PATTERN MOTORCYCLE VS RELATIVE SENSITIVITY

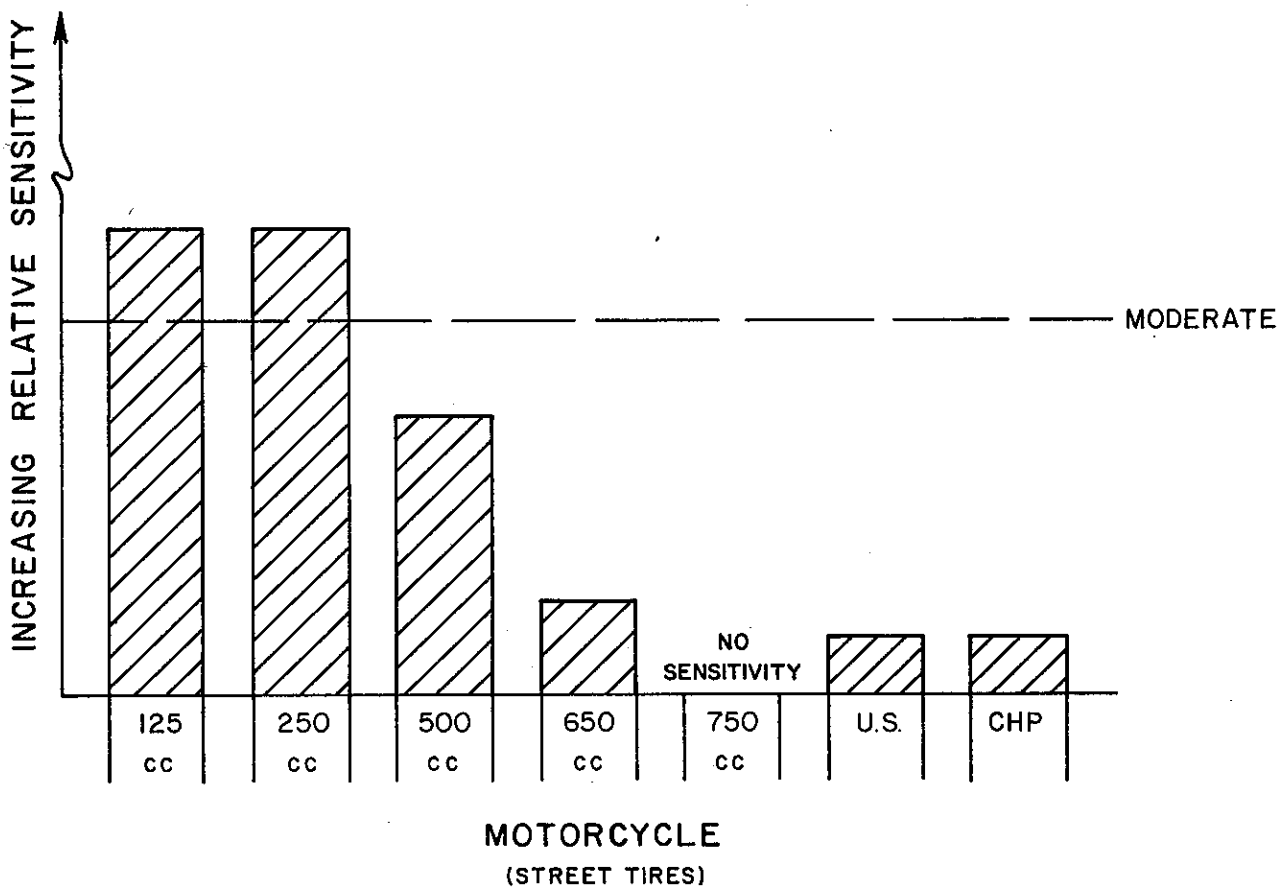
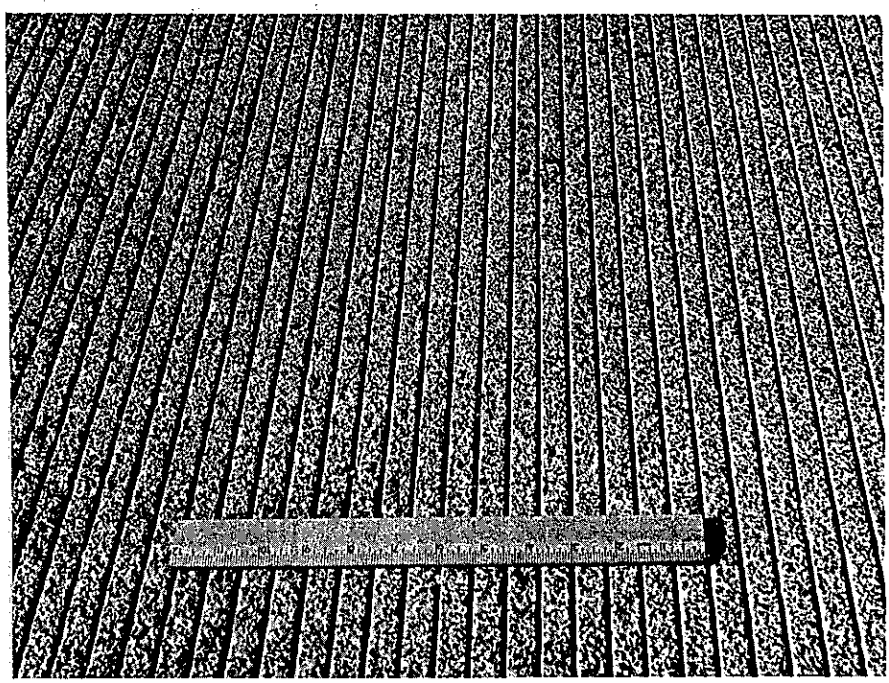


Figure 9

095" X 1/8" AT 3/4" CENTERS GROOVING PATTERN MOTORCYCLE VS RELATIVE SENSITIVITY



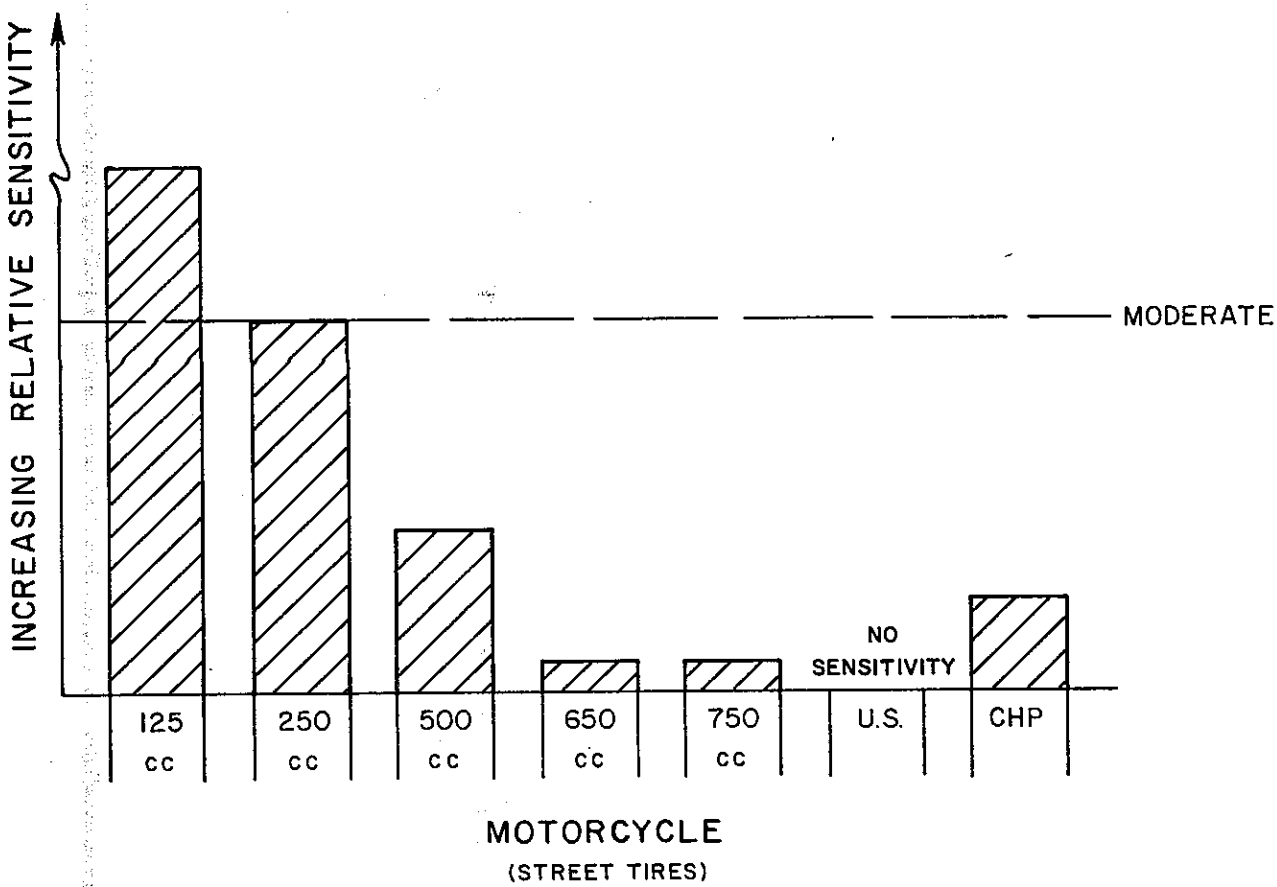
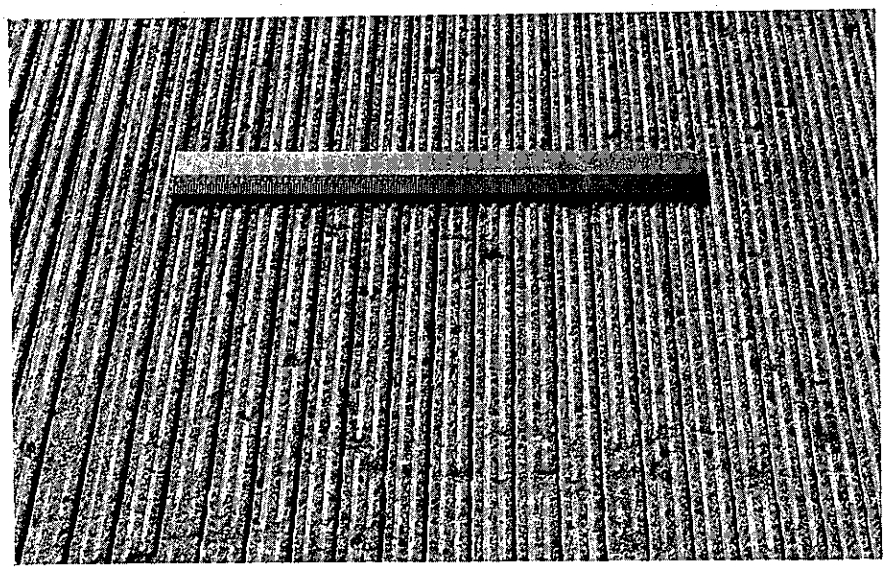


Figure 10

STYLE A GROOVING PATTERN
MOTORCYCLE VS RELATIVE SENSITIVITY



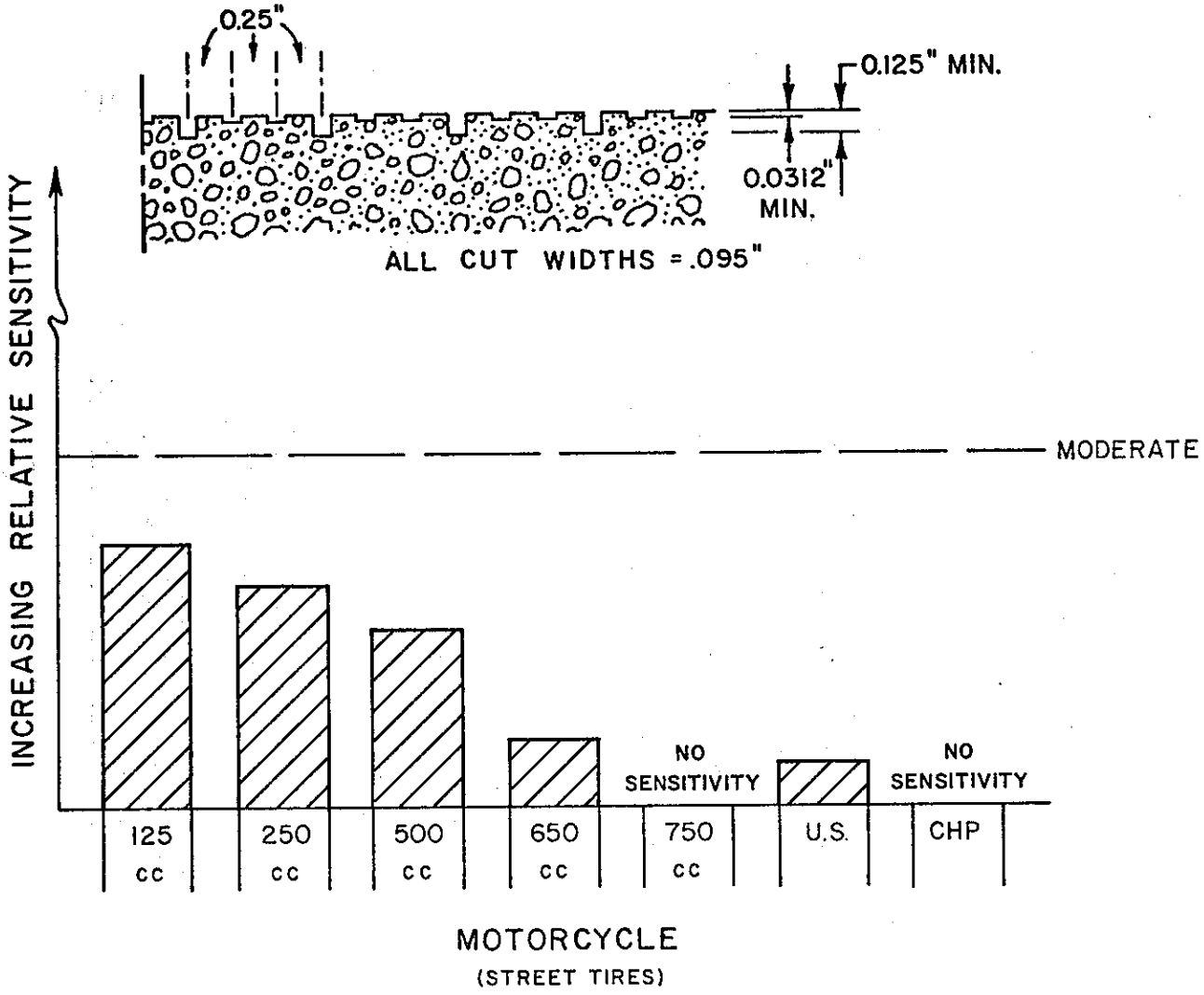
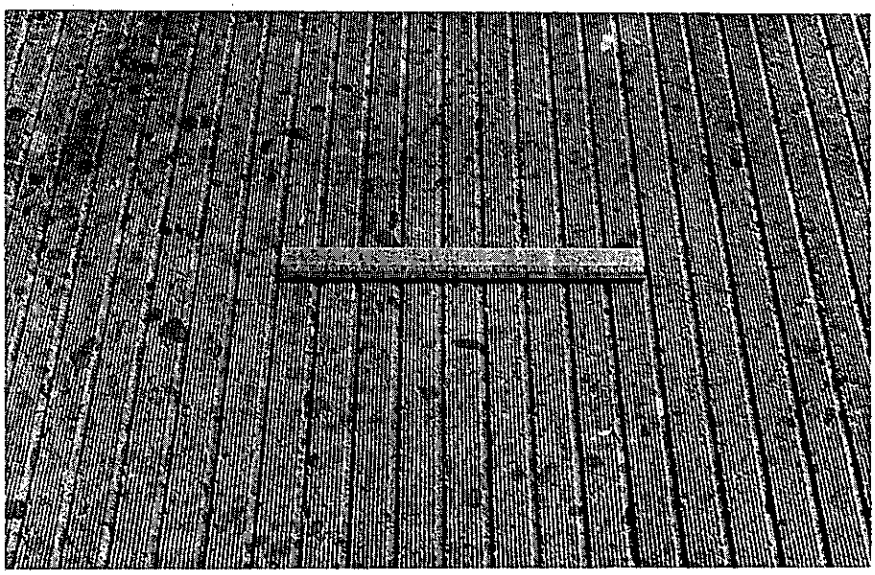


Figure 11

STYLE 15 GROOVING PATTERN
MOTORCYCLE VS RELATIVE SENSITIVITY



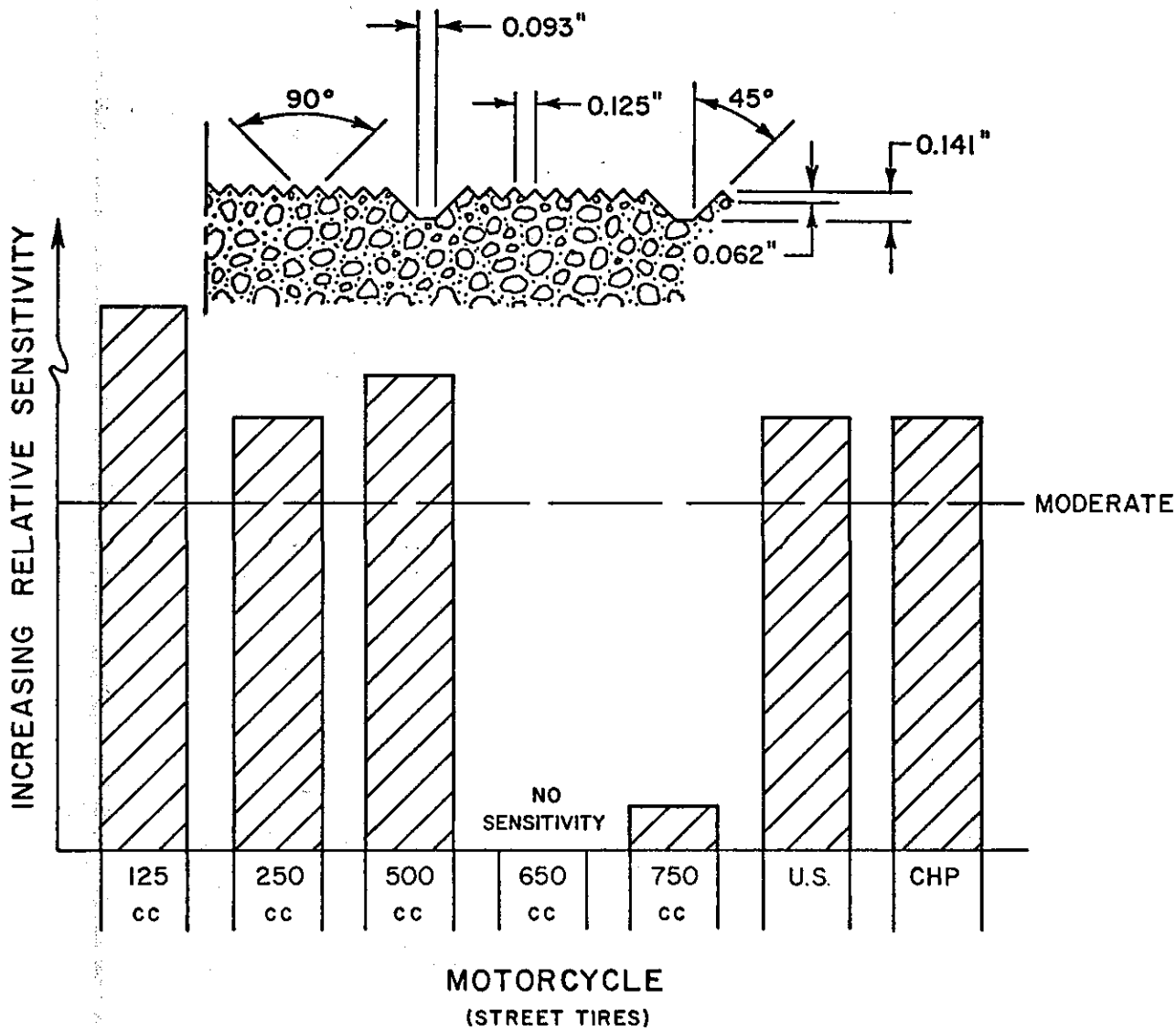


Figure 12

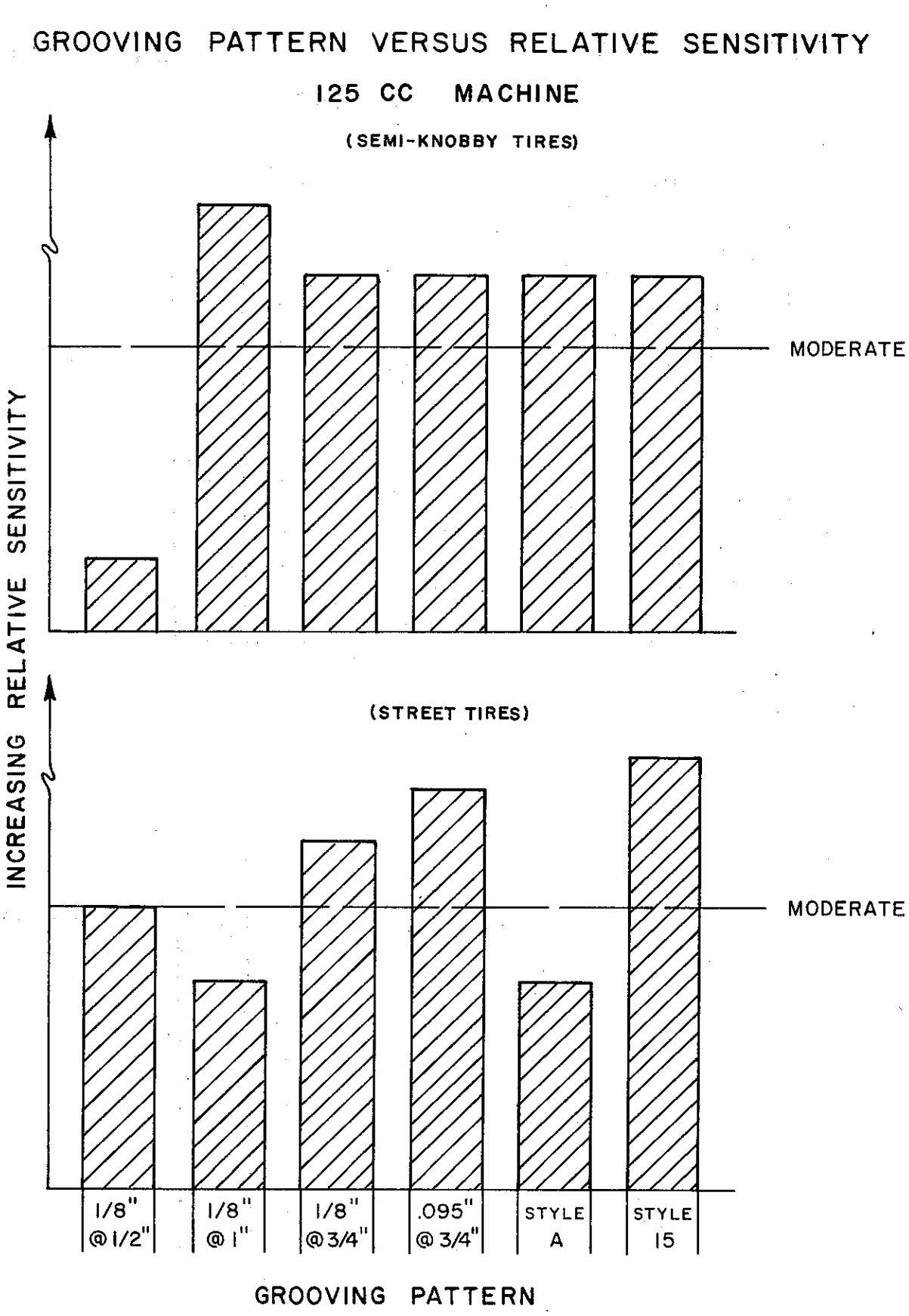


Figure 13

GROOVING PATTERN VERSUS RELATIVE SENSITIVITY

250 CC MACHINE

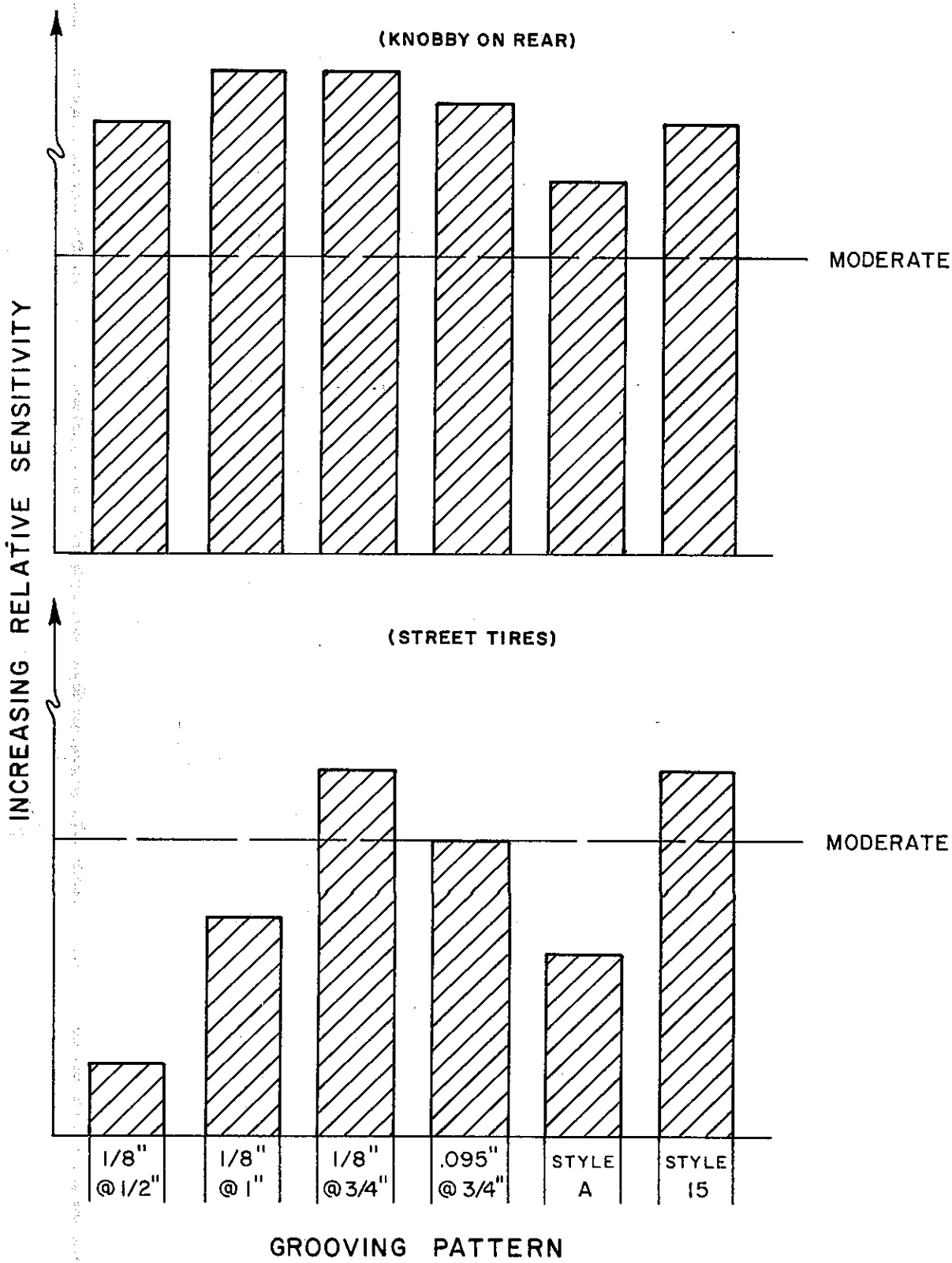


Figure 14

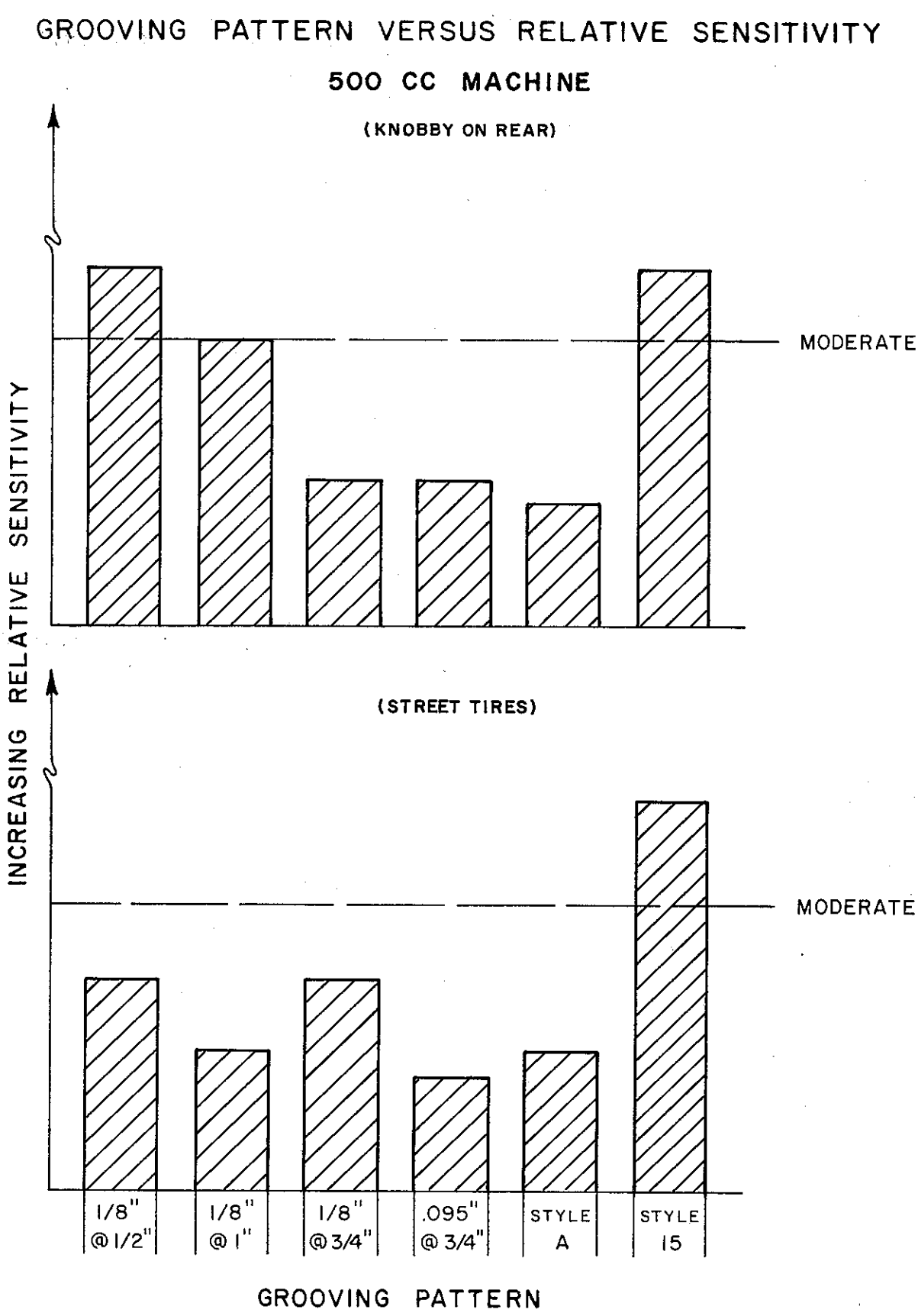


Figure 15

GROOVING PATTERN VERSUS RELATIVE SENSITIVITY

650 CC MACHINE

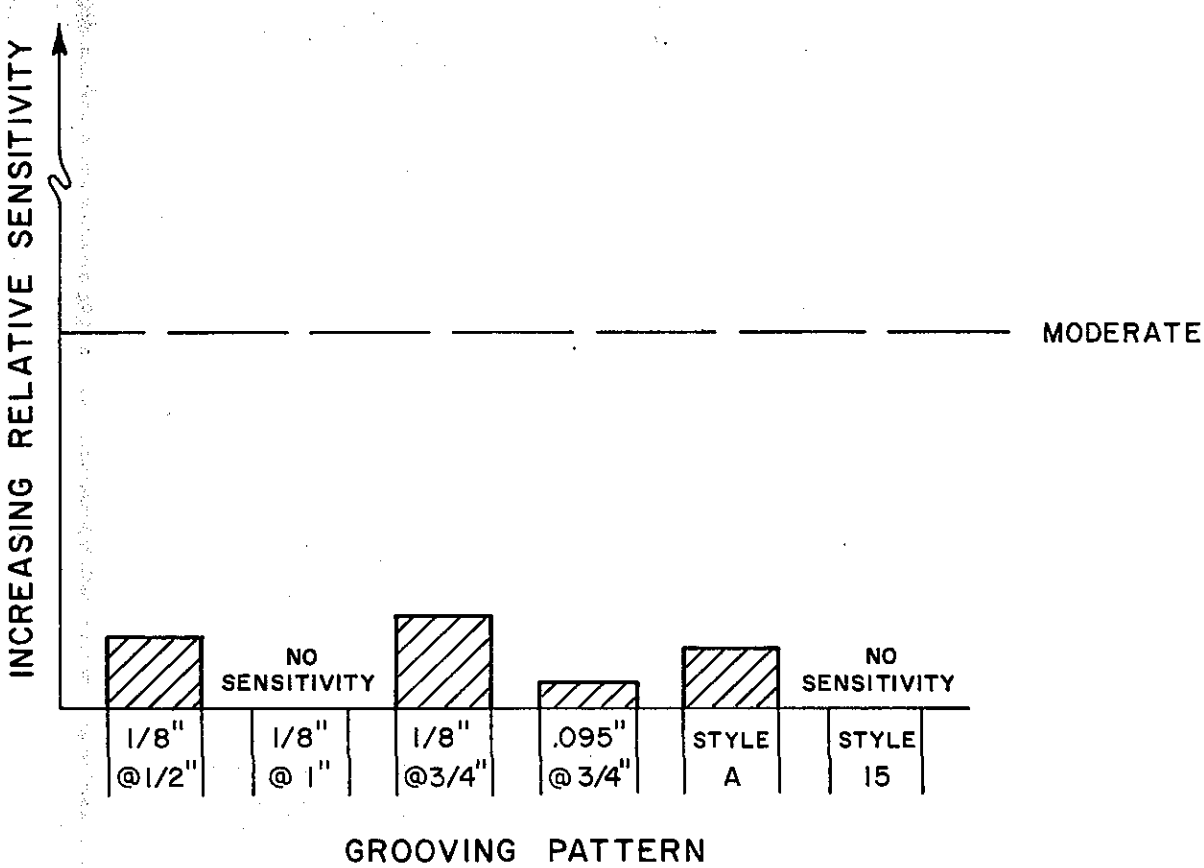


Figure 16

GROOVING PATTERN VERSUS RELATIVE SENSITIVITY

750 CC MACHINE

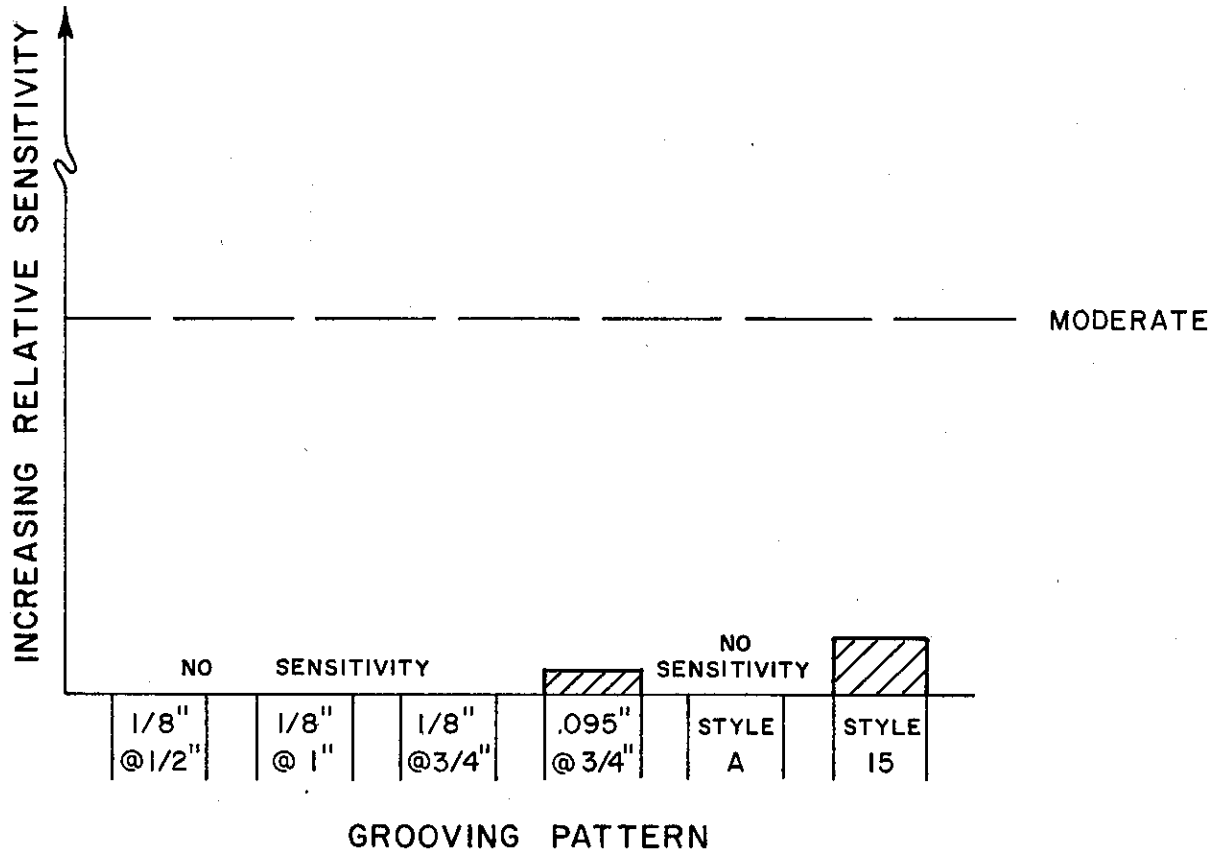


Figure 17

GROOVING PATTERN VERSUS RELATIVE SENSITIVITY

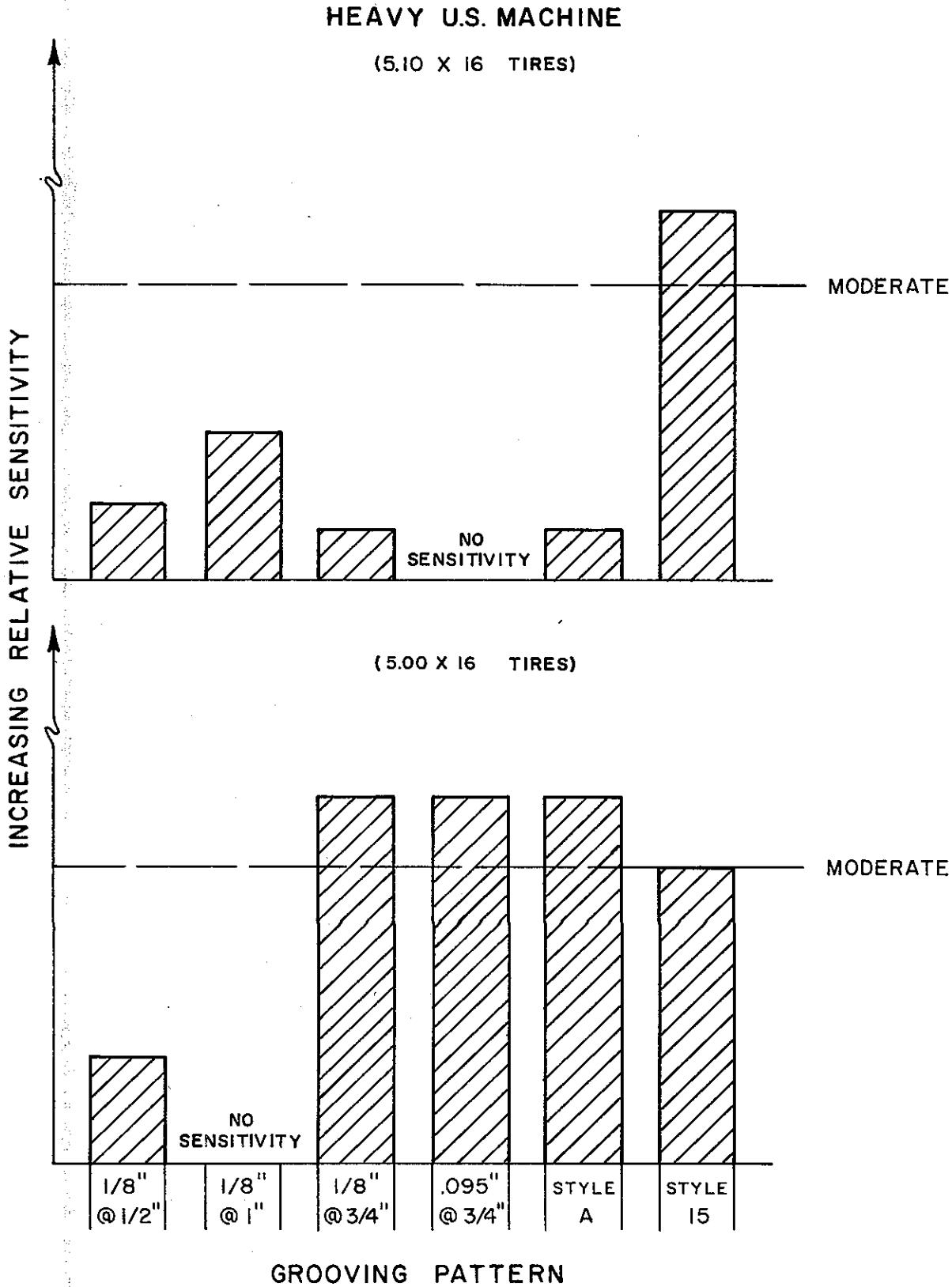


Figure 18

GROOVING PATTERN VERSUS RELATIVE SENSITIVITY

CHP MACHINE

(5.10 X 16 TIRES)